REVIEW OF TECHNOLOGIES FOR THE ONSITE TREATMENT OF WASTEWATER IN CALIFORNIA

Prepared for the
California State Water Resources Control Board

Center for Environmental and Water Resources Engineering
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NOTICE

Funding for this project has been provided by the State Water Resources Control Board (SWRCB). The contents of this document do not necessarily reflect the views and policies of the SWRCB, nor does mention of trade names or commercial products constitute endorsement or recommendations for use.

CONTENTS

ACRONYMS

Acronym	Meaning
α	Recirculation ratio
ATU	Aerobic treatment unit
BOD	Biochemical oxygen demand
BOD_5	Five day biochemical oxygen demand
$CBOD_5$	Carbonaceous five day biochemical oxygen demand
CFU	Colony forming unit
COD	Chemical oxygen demand
CWC	California Water Code
DF	Dosing frequency
DO	Dissolved oxygen
ES	Effective size
ETV	Environmental technology verification
FC	Fecal coliform
HAR	Hydraulic application rate
HLR	Hydraulic loading rate
LECA	Light expanded clay aggregate
LWA	Light weight aggregate
MPN	Most probable number
NH_3-N	Nitrogen as ammonia
NO_2-N	Nitrogen as nitrite
NO_3-N	Nitrogen as nitrate
NSF	National Sanitation Foundation
NTU	Nephelometric turbidity units
OLR	Organic loading rate
O&M	Operation and maintenance
ON	Organic nitrogen
PBF	Packed bed filter
PFU	Plaque forming unit
pH	Inverse log concentration of hydrogen ions
PLC	Programmable logic controller
PVC	Polyvinyl chloride
RF	Roughing filter
RSF	Recirculating sand filter
SBR	Sequencing batch reactor
SRT	Solids retention time
SWRCB	State Water Resources Control Board
TC	Total coliform

Acronym	Meaning
TF	Trickling filter
TKN	Total kheldahl nitrogen
TN	Total nitrogen
TP	Total phosphorus
TSS	Total suspended solids
UC	Uniformity coefficient
UV	Ultraviolet

TABLES

FIGURES

The State Water Resources Control Board (SWRCB) of California contracted with the Department of Civil and Environmental Engineering to conduct a review of onsite wastewater management systems. The results of the study are contained in this report. The information and findings presented in this report were derived from (1) information supplied by manufacturers, (2) the results of independent testing and reporting, and (3) information reported in conference proceedings and journals. Performance information from the report is summarized in the tables presented below.

The characteristics of typical septic tank effluent are provided in Table ES-1. A system for rating system performance is presented in Table ES-2. Available information on treatment system performance has been summarized in Table ES-3. When data were not available the performance rating was left blank.

Table ES-1
Characteristics of typical residential wastewater[a]

Constituent	Unit	Untreated	Septic tank effluent without effluent filter	Septic tank effluent with effluent filter
BOD_5	mg/L	450	185	135
TSS	mg/L	503	83	42
TN as N	mg/L	70.4	70	70
TP as P	mg/L	17.3	16	16
FC	no./100 mL	10^6	10^6	10^6

[a] Adapted from Crites and Tchobanoglous (1998).

Table ES-2
Classification system for onsite wastewater treatment system performance[a]

Rating	Biochemical oxygen demand (BOD), total suspended solids (TSS), and total nitrogen (TN)	Total phosphorus (TP)	Fecal coliform (FC)
A	< 10 mg/L	< 2 mg/L	< 2
B	< 20 mg/L	< 5 mg/L	< 800
C	< 30 mg/L	< 10 mg/L	< 2000
D	> 30 mg/L	> 10 mg/L	> 2000

[a] Based on values obtained from operational systems, independent certifications, and experimental systems.

Table ES-3
Summary of onsite wastewater treatment system performance

System description	Domain status	Status of technology	Expected performance[a, b]				
			BOD	TSS	TN	TP	FC[c]
Anoxic systems							
5-1.1 AWT Anoxic	Proprietary	In use			A		
5-1.2 Nitrex filter	Proprietary	In use			A		
5-1.3 Rock tank	Public	In-use			A		
5-1.4 RUCK	Proprietary	In use	C	C	B	B	D
Anaerobic systems							
5-2.1 Glendon biofilter	Proprietary	In use	A	A			B
5-2.2 UASB	Public	In-use	D				
Granular media, single-pass trickling biofilter systems							
6-1.1 Activated Carbon	Pubic	Experimental					A
6-1.4 Crushed brick	Public	Experimental	C	C		A	
6-1.7 Expanded Aggregate	Public	In use	B	B	C	A	
6-1.8 Glass (crushed)	Public	In use			C		
6-1.9 Glass (sintered)	Public	Experimental					B
6-1.11 Phosphex	Proprietary	In use				A	
6-1.13 Sand (uniform)	Public	In use	A	A			B
6-1.14 Sand (stratified)	Public	In use	A	A			B
6-1.15 Slag	Public	Experimental	B	B			
6-1.16 Zeolites	Public	Experimental					
Granular media, multi-pass trickling biofilter systems							
6-1.2 AIRR (sand)	Proprietary	In use	A	A			
6-1.3 Ashco-A RSF III	Proprietary	In use					
6-1.5 EnviroFilter	Proprietary	In use	A	A	C		
6-1.6 Eparco	Proprietary	In use					
6-1.7 Expanded Aggregate	Public	In use	B	B	C		
6-1.8 Glass, crushed	Public	In use	B	B	C		
6-1.10 Gravel	Public	In use	A	A	C		D
6-1.12 RIGHT	Proprietary	In use	A	A	C		
Organic media trickling biofilter systems							
6-2.1 Ecoflo	Proprietary	In use	A	A			D
6-2.2 Eco-Pure	Proprietary	In-use	A	A			B
6-2.3 Peat	Public	In use	B	B	B	C	A/B

System description	Domain status	Status of technology	Expected performance[a, b]				
			BOD	TSS	TN	TP	FC[c]
6-2.4 Puraflo	Proprietary	In use	A	A	D	D	C
6-2.5 Woodchip	Public	Experimental					
Synthetic media trickling biofilter systems							
6-3.1 Advantex	Proprietary	In use	A	A	A/B	D	D
6-3.2 Aerocell	Proprietary	In use					
6-3.3 Bioclere	Proprietary	In use	C	C	C	C	D
6-3.4 Rubber, shredded	Public	Experimental					
6-3.5 SCAT	Proprietary	In-use					
6-3.6 SeptiTech	Proprietary	In use					
6-3.7 Waterloo Biofilter	Proprietary	In use	A	A	B/C	C	C/D
Continuous flow suspended growth aerobic treatment systems							
7-1.1 AeroDiffuser	Proprietary	In use	A	B			
7-1.2 AES BESTEP	Proprietary	In use	A	A	B	C	
7-1.3 Alliance	Proprietary	In use	A	B			
7-1.4 BEST 1	Proprietary	In use	C	C			
7-1.5 Bi-A-Robi	Proprietary	In-use					
7-1.6 Brooks	Proprietary	In use	A/B	A/B			
7-1.7 Clearstream	Proprietary	In use	A	A			
7-1.8 Envirocycle	Proprietary	In use	A	A	C	D	
7-1.9 Hydro-action	Proprietary	In use	A	A/B			
7-1.10 JET Commercial	Proprietary	In use	B	B			
7-1.11 Mighty Mac	Proprietary	In use	A	A/B			
7-1.12 Modulair	Proprietary	In use					
7-1.13 Mudbug	Proprietary	In use	B	B			
7-1.14 Multi-flo	Proprietary	In use	A	A			B/C
7-1.15 Navadic	Proprietary	In use	A	A	A		
7-1.16 Singulair	Proprietary	In use	A	A			
7-1.17 Solar Air	Proprietary	In use	B	B			
7-1.18 USBF	Proprietary	In-use	A	A	A	A	
7-1.18 Whitewater	Proprietary	In use	A	A			
Sequencing batch reactor suspended growth aerobic treatment systems							
7-2.1 ABJ ICEAS	Proprietary	In use					
7-2.2 Aquarobic	Proprietary	In use	A	A			
7-2.3 Chromaglass	Proprietary	In use	A	A	A		

System description	Domain status	Status of technology	Expected performance[a, b]				
			BOD	TSS	TN	TP	FC[c]
7-2.4 EnviroSBR	Proprietary	In use					
7-2.5 NitroRaptor	Proprietary	In use	C	C	B		
7-2.6 SYBR AER	Proprietary	In use	A	A			
7-2.7 Thomas TRD	Proprietary	In use	A	A	B	A	B
Membrane bioreactor suspended growth aerobic treatment systems							
7-3.1 Kubota	Proprietary	In use	A/B	A	A	A	A
7-3.2 Zenon	Proprietary	In use	A/B	A	A	A	A
Continuous flow suspended growth with fixed internal packing							
8-1.1 Bio-fosse	Proprietary	In use					
8-1.2 Biomax	Proprietary	In use					
8-1.3 BioSorb	Proprietary	In use					
8-1.4 BTX Biotreater	Proprietary	In use					
8-1.5 EcoKasa	Proprietary	In use					
8-1.6 MicroFast	Proprietary	In use	B	A	B	B/C	D
8-1.7 JET BAT	Proprietary	In use	B/C	B/C	C	B	
8-1.8 Pirana	Proprietary	In use					
Continuous flow suspended growth with suspended internal packing							
8-2.1 Biogreen	Proprietary	In use	A		C	B/C	
8-2.2 Eco-kleen	Proprietary	In use					
8-2.3 Enviroserver	Proprietary	In use	A	A	A/B	A	A/B
8-2.4 Nibbler	Proprietary	In use	C	C	C		
Rotating biological contactors							
8-3.1 Biokreisel	Proprietary	In use	A	A	B/C	D	
8-3.2 Biorotor	Proprietary	In use					
8-3.3 CMS Rotordisk	Proprietary	In use					
8-3.4 Five Star KR505	Proprietary	In use					
8-3.5 Klargester Biodisk	Proprietary	In use	A	A/B	B	C	
8-3.6 Rotofix	Proprietary	In use					
Sequencing batch reactor with attached growth process							
8-4.1 Amphidrome	Proprietary	In use	B	A	B		D
Natural systems							
SF wetlands	Public	In-use	B	B	A	A	
SSF wetlands	Public	In-use	B	B	A	A	
Ecological systems	Proprietary	In-use	A	A	A	A	

System description	Domain status	Status of technology	Expected performance[a, b]				
			BOD	TSS	TN	TP	FC[c]
Evapotranspiration	Public	In-use	A	A	A	A	A
Lagoons	Public	In-use	C/D	C/D			

[a] Based on review of independent data from operational and experimental systems.

[b] Performance rating based on notation outlined in Table ES-2.

[c] Note that any process can eliminate fecal coliform with the addition of an effective disinfection process.

CHAPTER 1
INTRODUCTION

Approximately 3.5 million residents of California use onsite wastewater management systems. Onsite wastewater management systems can adequately provide water quality and environmental protection when properly designed, sited, constructed, maintained, and operated. However, when these conditions are not met, discharges from onsite systems may cause water quality impairments. Such impairment may include degradation of groundwater and surface water by nutrients, pathogenic microorganisms, pharmaceuticals, hormones, and other organic wastewater contaminants.

As development and population densities continue to increase in California, additional measures will be necessary to protect public health and environmental resources for persons living in the urban fringe and in rural areas not served by centralized wastewater collection systems. Recognizing the importance of onsite systems in California, Assembly Bill 885 was passed by the California legislature which added sections 13290 to 13291.5 to the California Water Code (CWC) (September 2000). This legislation requires the State Water Resources Control Board (SWRCB) to set minimum State standards for onsite sewage disposal systems by January 1, 2004. This action by the legislature will require codification of the standards as regulations in the California Administrative Code or implementation as statewide policy as well as completion of the California Environmental Quality Act process.

The purpose of this study is to compile information on onsite system technologies to assist the SWRCB staff in setting minimum standards for onsite wastewater treatment systems by the legislative deadline.

1-1 Background

For onsite wastewater treatment systems to be effective, they need to meet certain criteria. The factors identified in Table 1-1, presented on the following page, should be considered when selecting an onsite wastewater treatment system. With proper oversight, onsite wastewater treatment systems can provide high levels of treatment, including the removal of organic material, nutrients, and pathogenic organisms. Ongoing management of onsite wastewater treatment systems is necessary to maintain optimum performance and long-term sustainability. Recent developments in web based telemetry monitoring systems will make centralized management of onsite systems a feasible option. The technologies identified in this report represent the state of the art in onsite wastewater management, and reflect the factors identified in Table 1.

1-2 Scope of report

The information and findings contained in this report were obtained from (1) manufacturers and distributors of onsite wastewater treatment products, (2) the results of independent testing and reporting, and (3) information reported in conference proceedings and journals.

1-3 Report organization

To provide the needed information on the available technologies the report has been organized in the following chapters.

1. Introduction
2. Reducing Wastewater Generation
3. Non-Discharging (Containment) Systems
4. Primary Treatment Systems and Appurtenances
5. Anoxic and Anaerobic Systems
6. Trickling Biofilters (Attached Growth Aerobic Treatment Systems)
7. Suspended Growth Aerobic Treatment Systems
8. Combined Suspended and Attached Growth Aerobic Treatment Systems
9. Natural Treatment Systems

10. Disinfection Systems
11. Soil Adsorption Systems and Components
12. Monitoring and Control Systems

Appendixes

Following the introduction, a discussion of methods and technologies that may be used to reduce wastewater generation is presented in Chapter 2. Systems that do not discharge wastewater, and thus do not require a soil adsorption system, are presented in Chapter 3. Septic systems and associated products are presented in Chapter 4. Biological treatment systems that utilize various combinations of anaerobic, anoxic, and aerobic processes are discussed in Chapters 5 through 9. Technologies used for wastewater disinfection are presented in Chapter 10. Soil based adsorption and treatment systems are presented in Chapter 11. Technologies used for monitoring and control of onsite treatment systems are presented in Chapter 12. Useful unit conversions are presented in the Appendix.

A summary of onsite wastewater treatment system performance is also presented in the Executive Summary, contained in the front matter of this report.

Table 1-1
Criteria for selecting an onsite wastewater treatment system

Criteria for selection of onsite systems	Comments
Overall footprint	How much land area will a treatment system occupy? Is there sufficient space available at the site in question?
Capacity in case of system or power failure	If a power outage were to occur, how would the treatment system be affected? How would the duration of the power outage affect the process? What is the storage capacity in the event of a power outage?
Expected treatment performance	What level of treatment is required of the treatment system to ensure that the receiving environment (e.g., groundwater) and human health will not be compromised? What is the fate of dissolved and suspended organic materials, nutrients, pathogenic and non-pathogenic organisms, metals, hormones, pesticides, food additives, pharmaceuticals, and other personal care products?
Electricity usage	What is the electricity demand required to obtain the desired performance? Will changes in the energy market affect the appropriateness of a treatment process?
O & M requirements	What level of service is required to ensure proper operation? Does servicing require a skilled technician? Can the system be monitored remotely and data transferred to a central data management system? What components will wear out and need to be replaced? Will replacement parts be available?
Costs	Does the effectiveness of the treatment system justify the capital and installation costs of the system?
Sludge production	Will sludge or other products of the system require offsite management? Who will perform this service and how much will it cost?

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